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Elucidating the pathways between climate change, ecosystem services and poverty alleviation

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A rapid review of the current literature on the links between climate change, ecosystem services (ES) and poverty alleviation has identified 41 papers. Of these, 19 were considered relevant as they specifically discussed the linkages between ES and poverty and the influence of climate change on that relationship. The papers reviewed focused on a limited number of ES and rarely considered multiple dimensions of poverty or the full range of climate change effects. The authors collectively recognise a complex network of relationships between ES and poverty, further complicated by the potential impacts of climate change. There is an urgent need for empirical research and interdisciplinarity, including developing a commonly understood set of definitions, in order to begin to elucidate pathways that will significantly affect the abilities of people to adapt to our rapidly changing climate.

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Introduction

The Millennium Ecosystem Assessment (MA) was the first large-scale synthesis of the human consequences of ecosystem change, and concluded that the degradation and loss of ecosystem services (ES) affects poor and vulnerable people disproportionately and is a significant barrier to reducing poverty [1]. The environmental characteristics at a location affect both a community's access to and benefits from ES, which in turn determine the habitability and attractiveness of places and landscapes [2,3]. In addition to human activities, climate change is a direct driver of ecosystem change, which will therefore have significant knock-on effects on poor people, whose livelihoods are often heavily reliant on natural systems.

The pathways between ES and poverty alleviation are poorly documented and causal relationships are often inferred from correlative data. It is not clear whether this lack of evidence is the result of different bundles of ES and dimensions of poverty being considered by different groups of researchers, or simply a lack of empirical research into, and documentation of, these links. The causal links between climate change and ecosystem change are also poorly understood, as there are no detection and attribution studies that have focused specifically on ES [3]. Consequently, despite their importance for designing and implementing restorative actions, the influence of climate change on poverty alleviation through its impacts on ES is, as yet, little discussed in the peer-reviewed literature. Consideration of these relationships is emerging as a new field of enquiry in the grey literature, for example, the ecosystem-based adaptation support framework currently in development by United Nations Environment Programme [4].

In order to provide a basis for future work, this paper presents an overview of the potential and current understanding of the effects of climate change on the relationship between ES and poverty alleviation.

Methods and literature reviewed

Firstly, in order to elucidate the current knowledge of pathways and linkages between ES and poverty, a literature search of the ISI Web of Knowledge database was carried out in the second quarter of 2012 using the search terms and combinations given in Table 1. Only ISI journals were considered, as although there is an emerging literature on the subject within the grey literature,

Table 1

Literature review search terms and combinations

'*ecosystem**'	**AND**	'*poverty*'
'*environmental service**'		'*poverty eradication*'
'*ecosystem service**'		'*poverty reduction*'
		'*poverty alleviation*'

this was a rapid review of the peer-reviewed literature for a peer-reviewed journal. The search terms used were broad and generalised as people's definition of ES varies and therefore specifying the individual services was likely to have missed relevant papers. Different terminology for ES and poverty alleviation was also used in order to capture a greater number of papers. Finally the Boolean character * was used to increase the number of hits for pertinent studies. A rapid review that only considers certain search terms has a number of shortcomings, namely that a number of key studies will be overlooked. However, this article considers the narrower question of how researchers, who are interested in the manner in which ES may be utilised for poverty alleviation, view the potential effect of climate change on this relationship.

263 journal articles, in English, published between 2000 and March 2012 were retrieved. The year 2000 was chosen as representing the start of the MA, and a relatively consistent use of the terms ecosystems and ES. These papers were then searched for references to climate change, creating a final list of 41 papers. The search for references to climate change was done secondarily, as we were interested in how researchers view the impact of climate change on the relationship between ES and poverty alleviation. On reading the full articles, 19 were considered relevant as they specifically discussed linkages between ES and poverty and the influence of climate change on that relationship (see Appendix 1). Table 2 provides an overview of the type and scope of these papers, and it can be seen that there was only a small number of case studies undertaking new empirical research in order to understand these complex relationships.

Most of the papers reviewed did not provide details of the specific climate change effects that they were discussing and simply presented climate change as a driver of ES change in very general terms. Impacts from climate change were not limited to changes in temperature and precipitation; they may well include sea level rise, increases in ocean temperature, oceans acidification and natural hazards among others. Similarly only a limited number of ES and poverty measures were specifically identified in the reviewed papers.

Table 2

Summary of paper types and scope considered in the review

Paper type	Geographical scope	Journal type
14 discussion/review	12 global	9 conservation/ environment
5 case studies	3 China	2 agricultural
	1 Congo	2 physical
	1 Bangladesh	2 human
	1 India	4 general
	1 Solomon Islands	

The main services considered were supporting services — primary production, soil and nutrient cycling, climate regulation and some ecological interactions — and their links to provisioning services such as crop production and carbon sequestration. Limited attention was given to water regulation, species diversity, pest, disease and hazard regulation. Evolutionary processes, energy provision, pollution control and pollination were omitted entirely. Consideration of poverty emphasised financial measures (e.g. income and assets) and food security, and while energy and health were mentioned (although not discussed in detail), other aspects such as education, life expectancy, psychological wellbeing and social relations were not considered at all.

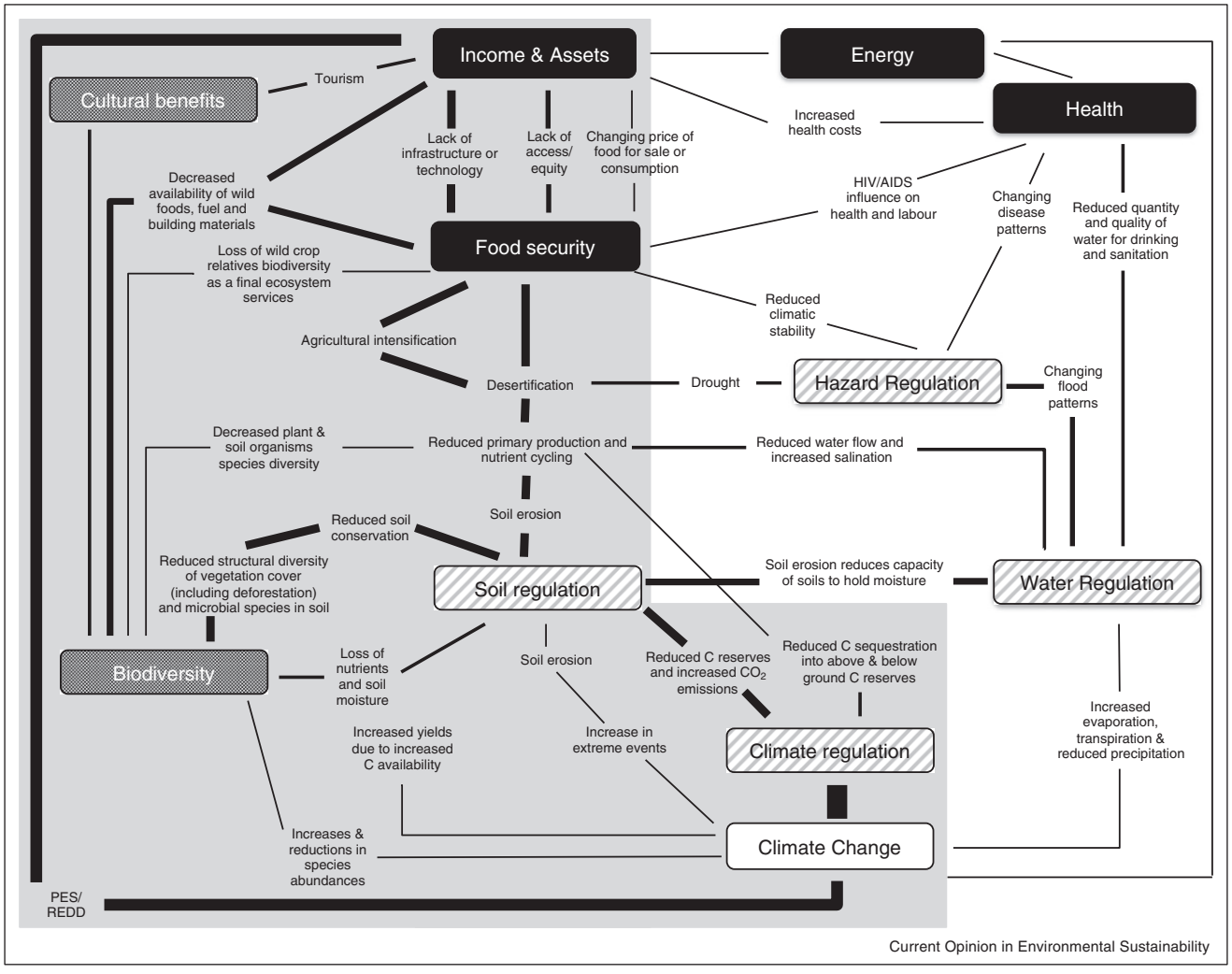
Because of the lack of clarity about the definitions of ES used, or which benefits were being described and which dimensions of poverty were under discussion, it was often unclear how the impacts of climate change on the relationship between ES and poverty were being assessed. In fact these impacts were more often assumed than documented.

Climate change impacts on the relationship between ecosystem services and poverty

Figure 1 illustrates the links between ES and poverty as described in the 19 papers considered. It also illustrates how climate change may affect those links via a number of pathways. The figure does not attempt to provide a definitive understanding of these links or to provide a direction or strength of effect, but shows the hypothesised impact of climate change on the ES–poverty alleviation relationship.

Climate change has an effect on three key ES that ultimately influence poverty. These services — climate regulation, soil regulation and water regulation — are not surprising considering their intimate relationship to food security and health; important poverty dimensions. Climate change also has a direct effect on biodiversity, which may or may not be classified as an ES (see Mace *et al.* [5] for further details). The process through which climate change affects these services is multi-faceted and can be both negative, for example, an increase in extreme events, or positive such as increased yields due to increased carbon availability. Climate change may also have a direct effect on poverty through interventions such as Payments for Ecosystem Services/Reduced Emissions

Figure 1



A black box indicates a measure of poverty, a white box with grey stripes an ecosystem service, the white box is climate change (there was insufficient information to describe different effects) and a grey box with white dots indicates factors that can be considered as ecosystem services. The different line weights illustrate the frequency with which those relationships were discussed. The large area with grey background illustrates those topics most commonly reviewed or investigated in the literature. Further detail is provided in the section on climate change impacts on the relationship between ecosystem services and poverty.

from Deforestation and forest Degradation (PES/REDD). However, the inter-links between different ES and dimensions of poverty are complex and by circumventing this relationship by targeting income and assets alone, PES/REDD schemes may leave themselves vulnerable to failure. The direct effect of climate change on other dimensions of poverty such as energy was only mentioned in one paper, and the mechanism by which this might occur was not examined in detail, highlighting a potentially large field of enquiry that is yet to be discussed. As Figure 1 shows, the main area of discussion was the effect of climate change on food security and income and assets through soil regulation, climate regulation and biodiversity. Considering the multidimensional nature of poverty and the variety of ES that might affect it, this finding demonstrates how little is understood about the impact of climate change on the ES–poverty relationship.

With regards to biomes, two ecosystems were noted as particularly vulnerable to climate change and its subsequent impacts on the ES–poverty interaction: drylands and mangroves. The papers reviewed consider drylands to be the most vulnerable terrestrial ecosystem to climate change; predicted to become hotter and drier with more erratic rainfall, and with these changes also interacting with desertification processes [6]. Climate change in drylands may also impair the maintenance and slow the rate of increase of the global carbon reserve [6]. Around one billion people, including many of the poorest, are

dependent on drylands, which means that climate change will have a significant negative impact on the poverty and vulnerability of many of the rural poor [7]. Mangroves are also noted as an important resource base for those living in coastal regions, and can play an important role in climate change mitigation strategies and hazard regulation [8,9].

The reviewed papers describe poverty, marginalisation and scarcity of arable land as increasing the pressure on rural inhabitants to continue over-exploiting the environment [10]. Ecosystem degradation in turn may undermine food production and the availability of clean water, threatening human health and livelihoods and increasing vulnerability to natural disasters and climate change impacts [11]. Further, climate change will alter patterns of net primary production and change growing conditions for many crops, ultimately changing their distributions [11,12], though these impacts will not be felt equally around the globe.

Agriculture is therefore identified as a key driver of impacts on poverty, even in areas where the majority of income is derived from non-farm activities [7], and agriculture is emphasised as an instrument of ecosystem management, of climate policy and of sustainable food production [13]. However, in drylands and mangroves, as well as in other ecosystems, conversion to agriculture causes significant depletion of the soil organic carbon pool [14]. The soil organic carbon is an important biomembrane that filters pollutants, reduces sediment load in rivers, decreases hypoxia in coastal ecosystems, degrades contaminants and acts as a major sink for atmospheric carbon dioxide and methane [14]. Hence, the maintenance and improvement of soils, particularly where conversion to agriculture has taken place is important for the management of carbon sequestration and storage [14]. Consequently, it is necessary to improve agricultural techniques to adapt and mitigate the effects of climate change in ways that do not enhance the cycle of poverty and ecosystem degradation. For example, low or no-till agriculture can help to improve soil quality, increasing carbon sequestration [12,14], whilst genetic improvements can allow for the development of high yielding and high quality crops and animal varieties [12,15].

The marketing of ES to enable better management and to alleviate poverty is a rapidly growing field of research, and payment schemes have been identified as mechanisms for adaption and mitigation of the impacts of climate change on ES and poverty. However, in order to do so successfully, the reviewed papers noted the importance of reconciling the short-term needs of the rural poor with the long-term revenue stream associated with markets [16], of ensuring prices are based on both off-site and on-site societal benefits, and that payments are high enough to compete with alternative land-uses in the short-term and long-term [14]. Further, because rules governing markets tend to be set by the more powerful sectors of society, it is important to ensure that the rural poor are not excluded from the exploitation of market opportunities [16–18]. It was also noted that gains from Reduced Emissions from Deforestation and forest Degradation (REDD) programmes may also be associated with a reduction in incentives for industrialised countries to decrease carbon emissions, the relocation of deforestation to places unaffected by REDD and loss of biological and cultural diversity that does not directly align with REDD measurement schemes [18].

Conclusion

This study addressed a relatively narrow question, and the limited breadth of the search terms, and the use of only peer-reviewed literature, meant that only 19 papers were studied. These are however most relevant, and we consider the sample to be sufficient, given that many researchers in the fields of climate change, ES and poverty will employ these terms. There may be bodies of literature that explore aspects of the linkages between ES and poverty in the context of climate change without referring specifically to these words (e.g. in the literatures on disaster risk reduction, energy and human health) but these often address different topics, and generally only consider single rather than bundled ES. As discussed in the methods, information is also emerging within the grey literature, although this is outside the scope of our study. While climate change effects per se are not the focus of this research, rather its impacts on the ES–poverty relationship, the consideration of these additional literature sets may provide further clarification and elucidation of significant links. It is therefore important that researchers in complementary fields are aware of this when choosing their key words. The limited scope of the papers in terms of climate change, ES and poverty measures may also be partially a result of the types of journals publishing the reviewed papers (Table 2).

Despite the widely discussed impact of climate change on the relationship between ES and poverty alleviation, we show here that papers on the topic focussed on a very limited number of ES and rarely considered the multiple dimensions of poverty. Similarly, analyses of climate change failed to explore the full range of effects that climate change may have on both the environment and on poverty. Drawing together the findings of these papers demonstrates that the pathways and links between ES and poverty and the impact of climate change on these pathways are complex. By failing to consider the linkages, feedbacks and multidimensionality of these three factors, it is difficult understand the system. Consequently, policies such as REDD that aim to reduce climate change, poverty and ecosystem degradation concurrently risk failure.

The lack of clarity of definitions and the paucity of case studies collecting new data demonstrates how difficult it is to draw strong conclusions regarding the effect of

climate change on ES–poverty relationships. This review therefore highlights the need for research that specifically attempts to reveal how these pathways work, based on clear hypotheses and assumptions, and emphasising the generation of new and relevant evidence to support policy design and actions on the ground. Earlier studies on human vulnerability assessments have explored the impacts of climate change on climate-sensitive diseases such as dengue fever [19]. While biodiversity and hazard regulation are not referred to specifically as ES in these studies, the links between ES and poverty dimensions (in this case health) and the impact of climate change have been identified. The field of human vulnerability assessments is rapidly growing, with work being done by UNEP and the Resilience Alliance among others [4,20]. These organisations are developing conceptual frameworks and future research in this area should draw on this important work. As detailed above, the term ES and perhaps even poverty may not be used and it is developing this common language between these different fields that will be key in furthering this work.

Recent evidence suggests that ES are most vulnerable to changes in three regions — the Mediterranean, low elevation coastal zones and small island states, and dryland margins [3]. Several studies in this review looked at drylands and mangroves, and explored small island states. However, if these areas are most vulnerable to a changing climate, then there is a need for new research that specifically investigates the effect of climate change on ES and poverty in these regions.

This rapid overview of the current literature demonstrates the complex inter-linkages between ES and poverty and the effect of climate change on this relationship, and highlights the importance of recognising these linkages when developing policies in these fields. This study also shows how little is understood regarding the mechanisms of these pathways and emphasises the urgent need for new empirical research and interdisciplinarity in order to begin to elucidate these pathways. Without such developments, we will struggle to develop ways to mitigate and adapt to our rapidly changing climate in order to protect both our vulnerable ecosystems and those who depend on them.

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